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PASSAMAQUODDY TIDAL POWER DEVELOPMENT

FINAL REPORT

OCTOBER 15, 1936

EXHIBIT D-8

UNITED STATES ENGINEER OFFICE
EASTPORT, MAINE

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DISTRICT ENGINEER
BOSTON, MASSACHUSETTS

WAR DEPARTMENT
United States Engineer Office
Eastport, Maine

EXHIBIT "D-8"

GEOLOGICAL REPORT ON
HAYCOCK HARBOR RESERVOIR SITE

C O P Y

WAR DEPARTMENT
United States Engineer Office
Eastport, Maine

March 21, 1936

MEMORANDUM TO CAPTAIN HUGH J. CASEY, CHIEF, ENGINEERING DIVISION:

I hereby transmit my geological report upon the Haycock Harbor Storage Reservoir Project. This report covers the 12 dam sites finally chosen but shortage of time for the preparation of this report has prevented including discussions of the 10 dam sites which were discarded for engineering reasons. Information on these can be found in the Preliminary Geological Report.

Additional field work had been planned at some of the sites but was not carried out on account of the cessation of work on this project.

Irving B. Crosby
Consulting Geologist

PASSAMAQUODDY TIDAL POWER PROJECT

GEOLOGICAL REPORT ON THE HAYCOCK HARBOR STORAGE RESERVOIR

BY IRVING B. CROSBY

CONSULTING GEOLOGIST

MARCH 1936

PASSAMAQUODDY TIDAL POWER PROJECT

GEOLOGICAL REPORT ON THE HAYCOCK HARBOR

STORAGE RESERVOIR

By Irving B. Crosby, Consulting Geologist.

ILLUSTRATIONS

PASSAMAQUODDY TIDAL POWER PROJECT

GEOLOGICAL REPORT ON THE HAYCOCK HARBOR STORAGE RESERVOIR

by

Irving B. Crosby, Consulting Geologist

INTRODUCTION

This geological report upon the Haycock Harbor Pump Storage Reservoir and the dam sites has been prepared at the request of Captain Hugh J. Casey. It supersedes the preliminary geological report except as regards those dam sites which have been abandoned for engineering reasons. This report is based upon extensive field studies and records and samples from numerous borings and test pits. The investigation has, however, been primarily of a preliminary character aimed to determine the feasibility of the projects and to enable decision to be made between the alternate sites. It was not expected to obtain in this investigation all the detailed information which would be necessary before final designs were made and construction commenced. For this latter purpose much additional field work, additional borings and test pits would be necessary at the sites chosen. In this report, however, the type of problems at each dam site are explained and the additional investigations needed are indicated.

The reservoir, as finally planned would involve 12 dam sites but 10 alternate dam sites were examined earlier in the investigation. It was first planned to have the power house in the vicinity of Haycock Harbor and four locations of the power house and five sites for Dam 1 were investigated. The use of Dam 1 would have involved the construction of Dams 16, 16A, 16B and also of Dam 2. When it was decided to change the site of the power house to the other side of the reservoir and locate it on East Stream, near the Whiting-Lubec road, all of these alternate sites of Dam 1 and also of Dam 16, 16A, 16B and 2 were abandoned and a new site for dam 8 here described as Site 8A was investigated. Dam site 1A, 1B, 1C, 1D and 1-F-1, also sites 16, 16A, 16B, 2 and 8 are not described in this report because they are not included in the present plan. Little information about these sites was obtained after the completion of the preliminary report, and descriptions of these 10 sites can be found in the preliminary geological report.

The dam sites described in this report are Site F which was referred to in the Preliminary Geological Report as 1-F-2, sites 3, 4, 5, 6, 7, 8A, 9, 10, 12, 13 and 14.

The flow line finally chosen for this reservoir was at an elevation of 120 feet. The crest of these dams would be at elevation 130. These elevations are used in this report. Raising the flow line would greatly increase the seriousness of the geological problems at some of the dam sites.

Many of the drill cores and samples were personally examined by the writer but in some cases shortage of time made this impossible and the descriptions prepared by Mr. Holmberg, Geologist, have been used. Questions pertaining to settlement of the clay and to seepage have been discussed with Mr. Hough and the results of tests made in the Soils Laboratory have been used.

The location of test borings was made by the Engineer in charge of this division of the Passamaquoddy Tidal Power Project or by his assistants. They were in general located to give engineering, rather than geological information though they have had to serve for the latter purpose also. More complete geological and foundation information could have been obtained from a smaller number of borings located for that specific purpose.

The geological field work had not been entirely completed when the investigation of this project was stopped. A number of test pits which were located on the ground had not been dug. Therefore the investigation of some of the dam sites is incomplete and the available information is of an uneven character, but in general those sites which are most important and at which the most serious problems occur have been the most thoroughly investigated.

An extensive investigation was made of areas in which borrow pits might be located to obtain materials for the construction of earth dams. Some 300 test pits, scattered over a wide area, were dug and many others had been located but had not been dug at the time work on this project was stopped. The information about deposits of embankment material, is, therefore, incomplete, and additional exploration would be needed if this project is carried out. Shortage of time has prevented the writer from personally working up this information about borrow pit areas but it has been satisfactorily done by Mr. Hall who had general supervision of the test pit program. His report has been reviewed by this writer and is approved and included as part of this report.

Generalized geologic sections have been made of two dam sites in order to show the type of geologic conditions and of problems at these sites. It is not to be expected, however, that these sections accurately portray the existing conditions or that bed rock will be found at exactly the elevation indicated on the sections. It is believed, nevertheless, that these geologic sections give a general picture and will be a help in understanding the practical problems of the sites.

GEOLOGICAL CHARACTERISTICS OF THE RESERVOIR BASIN

The Haycock Harbor Storage Reservoir would include the basin of East Stream and parts of several small, adjoining valleys. By damming the outlet valleys and low saddles a large reservoir would be made. This would require 12 dams according to the latest approved plan. Several of these dams would be large structures across outlet valleys but others would be small dikes across saddles.

Two different types of practical problems concerning the reservoir present themselves. These are conditions pertaining to the dam sites and conditions pertaining to other parts of the reservoir. This last concerns the tightness of the reservoir basin. The tightness of the reservoir basin and the suitability of the dam sites depend upon the conditions of two different types of formations: the bed rock and the glacial and recent deposits.

The bed rock formations of the Haycock Harbor Reservoir basin are diabase, rhyolite, a little shale of the Pembroke formation and the Quoddy formation. This latter consists principally of shale, slate, quartzose shale, quartzite and some schist. Diabase is by far the most common rock of the area but rhyolite underlies the western side of the basin. The Quoddy formation occurs in elongated belts which are of greater importance in relation to the dams than their number and area would indicate. This formation is less resistant than the other rocks, except the shale of the Pembroke formation, and valleys have been commonly eroded in it as is the case at Haycock Harbor.

Both the diabase and the rhyolite, but especially the latter, are cut by innumerable irregular joint cracks, often very closely spaced. These joints divide the rocks into blocks of greater or lesser size and make possible the movement of ground water through the rocks. In general, joint cracks become tighter with depth and may become planes of weakness rather than open cracks. The diabase of the Haycock Harbor region is, however, less fractured than that in the vicinity of Eastport. The fractured condition of the rocks would permit seepage under and around some of the dams, but it is probable that in all cases this can be remedied by a moderate amount of grouting. The movement of water through these rocks will not enlarge the cracks, since none of the rocks seen near the dams are soluble. No limestone is known near any of the dams.

The glacial deposits of this region are till, sand, gravel, and clay. The till is a heterogeneous, unstratified mixture of silt, sand, gravel, cobbles and boulders, with or without clay deposited directly from the ice. When the ice sheet retreated from this region the land stood lower than at present and was submerged beneath the sea, the limits of submergence being about 200 feet above the present sea level. The deposits of till were washed by the sea and partly removed and generally in the lower parts buried under a blanket of clay which accounts for the scarcity of exposures of till. Sand and gravel deposits of different forms occur in the region and several eskers, ridges of sand and gravel, and kames, knolls of sand and gravel, are known. In the lower parts of the region marine clay is the predominant deposit and is in places 50 feet or more thick. Its consistency varies from hard to soft. Its color is gray, except in places near the surface where it has been oxidized.

As regards the tightness of the reservoir basin, the presence of bogs in the basin indicate that these lower parts are tight but does not prove that the entire reservoir would be tight if the water level were raised. The diabase and rhyolite which nearly everywhere constitute the bed rock will not in general, although much fractured, allow important seepage. In a few cases narrow bounding ridges may need investigating. Excepting at these few places and at the dam sites the conditions of which are discussed separately seepage from the reservoir through the bed rock will be unimportant. The glacial deposits, except for the sand and gravel are relatively impervious and sand and gravel deposits are not known to form bounding ridges except at a few places such as near dam sites 5, 9 and 10. It is probable, therefore, that this reservoir basin can be made relatively tight.

The shore line should be carefully examined and wherever the bounding ridges are narrow their width at the flow line and the character of the material of which they are formed should be determined. It is improbable that any of the rock ridges will permit important seepage but where these ridges are composed of glacial deposits a very careful examination is recommended.

The special importance of seepage from this reservoir is due to the fact that all the water in it would be pumped and thus represent a definite expense and that the water would be salty and therefore seepage would be injurious to the surrounding land. Fortunately the adjacent land is generally of little value, and also there are few places where seepage would be sufficient to cause trouble. Therefore the actual losses from this cause should be small. The Lubec water supply is separated from the reservoir by a valley and by rock hills so that it is certain this water supply would not become contaminated by salt water from the reservoir. Although seepage from this reservoir would probably not be serious, it would be greater than the seepage from the Calais Reservoir.

The problems of the dam sites concern principally the possibility of seepage through pervious formations and of settlement of structures which would rest upon clay or silt. These problems are concerned principally with the conditions of the glacial deposits but the bed rock conditions can not be disregarded. It is believed, however, that wherever bed rock is known to be at or near the surface any apprehension about foundation conditions or about seepage may be dismissed for the present and that the study and treatment of detailed conditions may best be left for the final examination and preparation of the dam site.

The dam sites which would be used in forming a reservoir here are two general types: 1-those across stream valleys which are now partly filled with glacial deposits and 2- those across saddles in the hills. Each of these types has practical problems peculiar to it and recognition of the type to which a particular site belongs aids in understanding the problems of the site.

As regards the valley type of dam site the stream valleys are partly filled with glacial deposits in every place known. Even where the stream is now flowing over ledge a buried valley or greater or lesser depth is believed to exist nearby. The filling of such buried valleys if often of a pervious character. Due to this fact the bottom of the valley dam sites require careful geologic investigation and subsurface exploration and the possibility of buried valleys by-passing the sites must be studied. Consideration has been given to the possibility of buried valleys by-passing any of these dam sites and it is not believed that there is danger of any serious seepage from the reservoir occurring in that manner.

Buried valleys are known to lead from the reservoir basin at dam sites F and 12. At the latter site the valley is filled with sand and gravel and there is a seepage problem which must receive study and treatment if the dam is built. Sites F, 8, 12 and 13 are probably of the valley type.

The saddle dam sites cross saddles between rock hills. Rock is often at or near the surface in the saddle and the overburden is generally not clay. In at least two cases however, sites 3 and 7, the saddles are deeply buried and there is a settlement problem at 3 and a seepage problem at 7. Dam sites 3, 4, 5, 6, 7, 10, and 14 are probably of this type.

The submergence of this area beneath the sea in late glacial time is of great practical importance as regards this project. Extensive deposits of silt and clay were deposited in the glacial sea and often covered deposits of till or of sand and gravel. The blanketing of pervious beds by silt and clay has increased the tightness of the reservoir basin but the presence of clay at some of the dam sites makes them less satisfactory by introducing the problem of settlement.

The glacial sea washed and sorted part of the glacial till of this area thus greatly reducing it in quantity and increasing the amount of sand and gravel present, and silt and clay, deposited in the sea, concealed much of the till with the result that deposits of this material, excellent for earth dams, are here scarce. The difficulty of finding satisfactory deposits of suitable materials for embankment construction is due directly to the submergence of this area beneath the sea.

DAM SITE F

Dam Site F extends from the northern slope of the hill from which the rocky peak known as "Liberty Cap rises, northerly across a small brook to a plateau then turns northeasterly and crosses the valley of Wiggins Brook and extends along a ridge to the rocky hill at the end of Dam Site 3.

This site is the same as site 1-F-2 which was briefly referred to in the Preliminary Geological Report. At the time that report was written, no investigation had been made of this site except for a few general observations and no description was then given of it.

A dam on site F would take the place of Dam 1 for the five alternate sites of which geological discussions are given in the Preliminary Geological Report. Dam F would also make unnecessary the construction of dams at sites 16, 16A, 16B and 2.

The geological discussion of dam site F can well be divided into three parts; 1-The section across the brook valley north of Liberty Cap to the plateau above mentioned, 2- The section across the main valley of Wiggins Brook, from the plateau to the ridge northeast of the valley and, 3-That part along the ridge to the rocky hill at the end of dam site 3.

The first part of this dam site crosses a brook valley from a hillside in which rock is encountered near the surface, by boring 3-F-10, to a hillside in which test pit 3-F-FT-1 exposed bed rock at a depth of four feet. Boring 3-F-9 by the small brook encountered bed rock at a depth of twenty-nine feet indicating a buried bed rock valley beneath the brook. It appears probable that this boring is near the deepest part of the buried valley. Boring 3-F-8 on the plateau encountered bed rock at a depth of two feet. On the plateau between pit 3-F-FT-1 and boring 3-F-8, overburden is probably thin everywhere, the greatest probable depth being 10 to 15 feet. Part of the overburden is sandy and part of it is silty, but its character is unimportant on account of its thinness. It would provide stable foundations for an earth dam, and if further investigations by test pits should indicate pervious conditions a cut-off to bed rock would be a simple matter.

Under the brook, however, conditions are different. The boring here indicated ten feet of silt, underlaid by 19 feet of gravelly sand. This lower layer is very pervious and would allow considerable seepage if it were not effectively blanketed by the silt. If this blanket is continuous, seepage would be greatly reduced; therefore, if any further investigation is made of this dam site the continuity of the silt blanket and especially the conditions on the two sides of the brook valley should be carefully investigated.

The central part of this site extends from boring 3-F-6 on the plateau to boring 3-F-3 on the ridge northeast of Wiggins Stream. The western part of this section of the dam site is on the plateau and crosses a depression in which there is a small brook. The depth to rock and the character of the overburden in the vicinity of this brook is unknown, and further investigation would be needed. On the eastern part of the plateau at boring 3-F-7, the overburden is only four feet thick and is, therefore, of little importance. From this boring the dam line descends the gentle slope to the valley. The depth of overburden here is only moderate with a probable maximum of thirty feet. The lower part of the overburden is sandy and pervious but this is overlain by a silty layer. The continuity of this silt layer should be thoroughly investigated if this site is to be used.

Boring 3-F-5, near Wiggins Stream, encountered bed rock at an elevation of 35 feet or 14 feet below the surface. Although rock here is at a lower elevation than at any of the other borings, it is probable that this is not in the deepest part of the bed rock valley and that rock is lower between this hole and boring 3-F-4, some 1,100 feet to the northeast. At site 1A, described in the preliminary report, a buried valley 34 feet below sea level was found by the drill. This valley continues inland and is probably crossed by dam site F. Since, however, the valley is in shale at site 1A and only diabase was found at site F, it is probable that the buried valley is shallower at the latter site.

Boring 3-F-5 showed eight feet of clay overlying six feet of sand. In the deepest part of the bed rock valley, both the clay and the sand layers, are probably thicker since the surface is considerably higher and the bed rock is probably lower. The thick blanket of clay would effectively reduce the possibility of seepage through the sand, but a study of the settlement of the clay would be necessary. This section of the site may be considered as ending at boring 3-F-3 on the ridge east of Wiggins Stream. The overburden here is only nine feet thick, consisting of silty clay in the upper part, with a gravelly layer at the base. On account of the thinness of the overburden here and the character of the upper part there is no seepage problem, but between boring 3-F-4 and boring 3-F-5 the overburden is thicker and Pit 3-F-PT-6 indicates that it is sand and that there is no blanket of silt. The absence of a silt blanket here would permit seepage to enter the sand, and concentration of flow through this part of the overburden might cause piping. This part of the site should, therefore, receive very careful study if a dam is built here. Since, however, the depth of bed rock is not very great, probably not anywhere over thirty feet and possibly much less, it would not be difficult to prevent seepage, by a cut-off to bed rock or by other treatment.

The third section of the dam site may be considered as extending from boring 3-F-3 along the ridge to the eastern end of the site. This ridge consists of varying thicknesses of overburden on a bed rock ridge in which there are at least two saddles.

Boring 3-F-2 in the westerly of these saddles encountered bed rock at a depth of thirty feet. The overburden consists of twenty-six feet of silty clay underlain by a sand and gravel layer. It is probable that this boring is not in the deepest part of the bed rock saddle and that the sand and gravel layer is somewhat thicker elsewhere, and that possibly the clay is thicker also. If this thick clay blanket is continuous it would effectively prevent seepage through the sand layer. The possibility of settlement of the clay should be studied if a dam is to be built here.

East of this bed rock saddle, at pit 3-F-FT-9, bed rock is only two feet below the surface, but farther east at boring 3-F-1, bed rock is buried under twenty-three feet of overburden which consists of sixteen feet of clay underlaid by seven feet of sand and gravel. Here again the continuity of the clay is important for if it is continuous it will prevent seepage. It is not certain that this hole is in the deepest part of the bed rock saddle, the clay may be thicker at some other place and there may be a minor settlement problem here.

East of this, at pit 3-F-FT-10, bed rock was only three feet below the surface at an elevation of one hundred and twenty-two feet. Between this point and the hill at the end of Dam 3, the overburden is sandy and the elevation of bed rock is unknown, but is probably high. Further investigation of the thickness and character of the overburden would, however, be needed at this end of the dam site to make certain that there could be no seepage around the end of the dam.

The available information indicates that this is a feasible and fairly satisfactory dam site and that there is no serious seepage problem, but a careful study of the continuity of the silt blanket would be necessary and it may be desirable to artificially extend this blanket. Present indications are that the seepage under this dam may be in the order of one-half cubic foot per second. There is probably no serious settlement problem here, but the conditions in the vicinity of Wiggins Stream and possibly at two other places, would require further investigation.

DAM SITE 3

Dam Site 3 connects two rock hills and crosses a broad boggy saddle. The length of the dam would be approximately 2,100 feet and the height from the lowest part of the saddle to the crest would be 37 feet. A long ridge, upon which no ledge was seen, descends southerly from the rock hill at the northern end of the site. Bed rock is at considerable depth under the saddle and was 44 feet beneath the surface, at elevation 50, in boring 3-3-1. Bed rock outcrops on the hillside near the southwestern end of the dam.

The two problems requiring attention are seepage through sand and gravel under the dam and settlement of structures founded upon clay. For convenience in study of these problems the site may be divided advantageously into three parts: 1- The long flat topped ridge at the northeastern end of the site, 2- the saddle in the south-central part of the site, and 3- the hillside at the southwestern end of the dam site.

Boring 3-3-4 at the lower end of the ridge at the northeastern part of the site penetrated 10 feet of clayey silt with scattered pebbles, below which is 9 feet of sand and gravel, with cobbles and small boulders. The upper material is probably relatively impervious but the lower material is certainly pervious. No other borings were made in this ridge but 4 shallow test pits showed variable mixtures of silt, sand and gravel, which are probably relatively impervious. Boring 3-3-4 indicates, however, the possibility that this impervious material is underlain by pervious sand and gravel. This ridge is blanketed to an elevation of over 100 feet, 114 feet at boring 3-3-4, with silt and clay. It does not appear probable that there could be a very serious seepage problem here but if a dam is to be built on this site a very thorough investigation with borings and additional test pits should be made of this ridge.

Boring 3-3-5 and two test pits show glacial till, which is relatively impervious, on the slope at the southeast end of the dam site. Therefore, it is improbable that there would be any seepage or other problems here.

Three borings were made in the boggy saddle between the ridge and the hill at the southwestern end of the site. Each of these borings penetrated a layer of silt and clay under which is a bed of sand and gravel. The clay layer is a very effective impervious blanket which is probably continuous for some distance but the conditions at the edges of the saddle should be investigated. It is improbable, however, that there would be any seepage problem on this part of the site. At these three holes the clay or silt are overlain by 4 to 8 feet of peaty material which it would be necessary to remove. Boring 3-3-1 penetrated 26 feet of silty clay and hole S-3-3 went through 25 feet of similar material. These facts indicate that there is a settlement problem here but it is probably not serious.

This is a feasible dam site with two problems which need further study. These are the possibility of settlement in the saddle and of seepage through the ridge at the northeastern end of the saddle.

DAM SITE 4

Dam Site 4 crosses a valley from a rocky hill on the south to a small ridge which is separated from the northern hillside by a depression, the lowest part of which is well above the crest of the dam. A dam here would be approximately 1,000 feet long with a maximum height to the crest of only 18 feet. The valley is boggy and is underlain by clay or silt which was encountered in the three borings. Boring 3-4-2 by the brook on the lowest part of the dam line penetrated 27 feet of clayey silt before reaching slate bed rock at elevation 86. Boring 3-4-3 on the northern side of the saddle struck quartzite bed rock at elevation 83 after penetrating 26 feet of overburden which consisted of 5 feet of clayey silt, 5 feet of fine sand, 20 feet of sandy clay and at the bottom 6 feet of sandy silt and silty sand with fine gravel. Probably none of this material is very pervious and even the upper layer is blanketed with 5 feet of clayey silt. Boring 3-4-1 near the southern end of the dam encountered diabase under 8 feet of overburden and consisted of 7 feet of clayey silt over 1 foot of gravelly sand. The information from these three borings and from the test pits make it certain that there is no seepage problem here.

The presence of at least 27 feet of clayey silt does, however, introduce a settlement problem. It is not at all certain that any of these three borings have found the lowest part of the bed rock surface and it is possible that the silt and clay may be thicker than is shown by the borings. This must be taken into consideration in studying the settlement problem and planning for a dam at this site.

The bed rock at this site is diabase on the southern side of the valley and shale and quartzite under the valley. The bed rock conditions are entirely satisfactory for this low dam.

This is a feasible dam site with no seepage problem, and the only problem requiring further study is concerned with settlement of the clay. Due, however, to the low height of the dam the settlement problem cannot be serious.

DAM SITE 5

Dam Site 5 crosses a small saddle, the lowest point of which is at elevation 126, or 6 feet above the flow line. Therefore, only a low dike would be necessary here. The dam would be on a low gravel ridge between two boggy areas and would connect the eastern point of a large gravelly ridge with the western point of a similar ridge. Two borings were made at this site. Boring S-5-1 was 43 feet deep and did not reach rock but boring S-5-2 encountered slate bed rock at a depth of 44 feet at elevation 83. Silty, sandy gravel was found in both holes, and in the shallow test pits. The material is not very pervious and since the head here is so small there is no seepage problem at this site. There is obviously no settlement problem here.

This is an entirely satisfactory site for the low dike which is planned here.

DAM SITE 6

Dam site 6 crosses a small saddle between a rock hill and a rock ridge which connects with the northern end of dam site 7. A small rock ridge divides the saddle longitudinally into two parts. The elevation of the lowest part of the eastern saddle is 121 feet or 1 foot above the flow line and the lowest part of the western saddle is 126 feet. Therefore, a dam here would consist of two low dikes. Rhyolite bed rock is exposed on the hill at either end of the saddle but boring S-6-1 encountered slate at a depth of 4.6 feet in the saddle. The overburden consists of clayey and sandy silt but since it is so thin its character is of little practical importance. It is improbable that the overburden is anywhere thick. There is obviously no seepage or settlement problem at this site and it appears to be a very satisfactory dam site for these small dikes.

DAM SITE 7

Dam site 7 extends from the easterly side of the rock hill at the east end of dam site 8, northeasterly along ridges and across saddles to the rock hill at the west end of dam site 6. It is divided into two parts by a rock knob which rises above the flow line. The southern part of the site is approximately 2,200 feet long and the northern part 4,100 feet long. There are practically two separate dam sites here, the geological characteristics of which are very different and they will, therefore, be considered separately the southwestern part being discussed first.

The southern part of the site would require a long low dam, between two rocky hills, across a broad saddle, the lowest part of which has an elevation of 95 feet on the dam line. The maximum height of dam here would, therefore, be 35 feet. Rhyolite bed rock is exposed on the hills at both ends of the site but is deeply buried under the center of the site. Five borings were made at intervals across this saddle. At one of these a deep test shaft was sunk to rock. Five shallow test pits were also dug. The lowest bed rock encountered by the borings was at hole S-7-6, at which the test shaft was subsequently sunk. Bed rock was here encountered at an elevation of 57 feet or 50 feet below the surface. It is possible, however, that bed rock is a little lower, a short distance to the westward of this boring. The overburden as disclosed by the borings and test pits is predominantly sandy but is somewhat silty in the upper part. The silt does not, however, form a continuous blanket over the sand and therefore would not prevent seepage through the sand. Seepage is the predominant problem at this site and treatment, such as an extensive impervious blanket on the reservoir side of the dam, would be necessary if a dam were to be built here.

The scanty information available indicates that without treatment the seepage under this part of the dam site might be in the order of two cubic feet per second. There is no settlement problem or other important problem, except seepage on the southwestern part of site 7.

From the rocky hill at the eastern end of the southwestern part of the dam site, the dam would cross a small saddle in which boring S-7-3 showed eleven feet of overburden, consisting of nine feet of clay, underlain by two feet of gravelly sand. If this clay blanket is continuous there would be no seepage problem here.

Easterly from this small saddle the site is on a high, rocky ridge which rises above the flow line in one place. This ridge consists of rhyolite and an inclined boring, S-7-1, showed that this rock is in excellent condition and is fairly tight. It may be desirable to use a concrete structure for that part of the dam on this ridge and the bed rock offers excellent foundations for such a structure.

Northerly from this ridge the dam would cross a saddle in which boring 3-7-8 penetrated 24 feet of overburden. The upper nine feet of this overburden is pervious but seepage through it could be intercepted by a cut-off. The lower part is clay through which there would be no seepage, but there might be a minor settlement problem here.

Northeasterly from this saddle the dam site crosses rock ridges and knobs between which are depressions. Five borings were made along this part of the site. At three of these borings, numbers 3-7-12, 3-7-13, and 3-7-14 the overburden is thin being 4, 6, and 11 feet respectively. Any possible seepage could be intercepted by a cut-off. At borings 3-7-10 and 3-7-11 is an effective clay blanket, which if continuous, would prevent any seepage.

Available information is inadequate on this part of the site, but it is improbable that there is any important seepage problem here. In some of the boggy depressions there may be minor settlement problems, but it is believed that these can be reduced or obviated by taking full advantage of the rock ridges and knobs. The northeastern end of this dam would connect with a hill of rhyolite.

This appears to be a feasible dam site. There is a seepage problem in the southwesterly part which would require treatment. The northeasterly part appears to have no serious problems but further investigations and careful location of the dam to take advantage of the topography and geology are recommended.

DAM SITE 8A

Dam site 8A would take the place of dam site 8 and was planned to permit the location of a power house at tide water in Cobscook Bay. The dam site extends between two rock hills, the same hills as those at the end of dam site 8, but it crosses East Stream one third of a mile northwest of site 8. A dam here would have a power house located in the valley of East Stream, near the Lubec-Whiting highway and at the head of tide water in Cobscook Bay.

The dam on site 8A would not be straight but would have two sections, the northeastern one extending from the power house site easterly to the rock hill at the north end of site 8 and the southern part extending from the power house site southerly to another rock hill. There are thus three distinct parts to this dam site, the geological conditions of which will be discussed separately. These are: The southern section and the northeastern section of the dam site, and the power house site. In addition the conditions along the tail race channel, which would extend from the power house to deep water in Cobscook Bay, will be discussed.

The northern section of the dam would extend easterly from the power house site along a ridge in which bed rock is exposed at a number of places. No borings or other sub-surface exploration had been made along this line. If a dam is built here test pits would be needed in the gaps between outcrops, in order to determine the character of the overburden and find out whether there would be any possibility of seepage. If such were found to be the case a cut-off to rock would probably be a simple matter. Rock is probably near the surface everywhere along this line, and it is reasonably certain that there will be no settlement problems.

The rock of this ridge is diabase and rhyolite. Both of these formations are intersected by innumerable cracks but they will provide firm foundation for any type of dam. It is possible that there may be seepage through some of the more fractured zones in the rock and the desirability of local treatment of the rocks should be studied when final investigations are made and the dam site is stripped for construction.

The section of the dam site south of the power house crosses two rock ridges and two buried valleys and ends on a rock hill at the southern end of the site. Immediately south of the stream a rock hill rises nearly to the flow line, and south of this is a buried valley, in which boring S-8-18 encountered rock at elevation 11 or 43 feet below the surface. It is not at all certain that this boring is in the deepest part of the bed rock valley. The overburden at this hole consists of 21 feet of clay with laminae of fine sand, below which is 22 feet of sand and gravel with numerous cobbles and boulders. This lower layer is probably pervious but is effectively blanketed at this hole by the overlying clay. The continuity of the clay should be thoroughly investigated, especially at the sides of the valley to make certain that it will not be possible for water to get under or around this clay blanket and pass under the dam in the layer of sand and gravel.

South of this buried valley is a rock ridge and south of this is another buried valley, in which boring S-8-19 encountered rhyolite bed rock at elevation 17 or 43 feet below the surface. This boring is probably not at the deepest part of this buried valley. The overburden consists of 40 feet of silty clay with sand laminae, below which is a three foot layer of sand and gravel in which an artesian flow of water was encountered. This basal layer is obviously pervious but it is effectively blanketed. The condition of this clay blanket should, however, be carefully investigated along the edges of this valley to make certain that there is no opportunity for water to enter the pervious layer under the clay. The possibility of settlement of the clay should be studied if a dam is built here.

The Power House Site.

The power house site is on East Stream near the Lubec-Whiting Road. A belt of shale crosses the stream here and immediately south of this is a belt of diabase, the contact of the two being south of the road. Two of the borings indicate rhyolite between the shale and diabase. This shale is the Leighton shale of the Pembroke formation. It is a blueish-gray shale, thin bedded and often forming flagstones. The outcrops of it are much weathered and the rock splits, not only along the bedding plain but along a plane of incipient cleavage. The stratification is on edge striking across the stream. This is not an ideal rock for the foundations of heavy concrete structures but the foundation can be made satisfactory.

Seven borings were made along the stream south of the road. Hole S-8-7 on the south side of the stream penetrated 40 feet of rhyolite in good condition and the core recovery was reported as 84 percent. Boring S-8-8 on the north side of the stream penetrated 42 feet of hard siliceous slate, in good condition, with no evidence of large open fractures with one possible exception. The core recovery was 81 percent. Boring S-8-9 on the same side of the stream penetrated a similar slate from which the core recovery was 72 percent. These three borings are up stream from a small ridge. If the power house was located here the foundation, as indicated by these borings, would be good but it would be necessary to excavate a great length of tail race. Just down stream from this ridge boring S-8-11 penetrated 51 feet of much altered slate and diabase. The rock was much fractured and in poor condition as was shown by a core recovery of only 29 percent. Boring S-8-10 about 140 feet northeast penetrated 24 feet of rhyolite in good condition, with a core recovery of 87 percent. Boring S-8-13, about 200 feet northwest of S-8-11 and on the opposite side of the stream penetrated 15 feet of rhyolite in good condition, from which the core recovery was 100 percent. Boring S-8-12, 140 feet northeast of this last hole penetrated 38 feet of slate with a core recovery of 83 percent.

These four borings indicate that in this area the foundation conditions are variable and that in at least one place, boring S-8-11, they are poor. The power house would require deep excavation and at that level the rock might be in better condition, but it is not so indicated by the borings. It is probable that very thoroughly grouting would be necessary to obtain satisfactory foundation conditions.

Three borings down stream from the highway bridge show that for a distance of at least 600 feet the rock is shale, siliceous in part, the core recovery varying from 50 to 100 percent. Location of the power house downstream from the road would lessen the amount of tail race excavation necessary but would considerably increase the length and height of dam.

It appears from the available information that the foundation conditions downstream from the road would be at least as unsatisfactory, and possibly more so, than those upstream from the road. The best location appears to be in the vicinity of borings S-8-7 and S-8-8, but this would involve the greatest amount of tail race excavations and would possibly be the most expensive. It is probable, therefore, that it would be necessary to locate the power house where the rock under at least part of it is not satisfactory and that elaborate treatment of the rock foundations would be necessary.

About one third of a mile west of the highway bridge East Stream passes between two rock knobs. The distance from rock shore to rock shore is only 100 feet and boring S-8-17 encountered slate bed rock at elevation -4. Bed rock is lower than this upstream indicating that the stream is not now following its bed rock valley. It is possible that a deeper, buried, bed rock valley exists immediately south of the rock knob on the southern side of the stream. Investigation of this area by borings is recommended since it is possible that the amount of rock excavation necessary for the tail race can be reduced by taking advantage of the buried channel of the stream. Considerable rock excavation will be necessary to obtain a tail race channel, but by additional sub-surface investigations this can be reduced to a minimum.

Dam Site 8A is a feasible dam site with possibly a settlement problem but the major problem regards the bed rock foundations of the power house which will probably require careful treatment. The location of the tail race channel also requires additional investigation.

DAM SITE 9

Dam site 9 would cross a small valley from a rock hill on the east side to a large gravel ridge on the west side. Midway between the hill and the ridge is a very small brook which drains a heath to the south. Immediately south of the brook is a large knoll composed of sand and gravel. Bed rock is exposed in the brook and in many places on the slope to the east but is concealed west of the brook.

The brook divides the dam site into two nearly equal parts which have entirely different geological and foundation conditions. East of the brook, bed rock is near the surface. There is little or no clay and there can be no question of settlement. Test pits in between outcrops, to determine the character of the overburden and the possibility of seepage would, however, be desirable. On account of the thinness of the overburden it is most probable that if any pervious material is found a cut-off to bed rock would be a very simple matter.

Boring S-9-2 at the brook, and boring S-9-1, east of the brook, encountered slate bed rock at elevations of 95 and 111 feet respectively. Ledges of slate were also seen on this slope. This slate is relatively hard and in good condition and will provide an entirely satisfactory foundation for this dam. It is doubtful if it will at any place require any kind of treatment.

West of the brook conditions are not so favorable. The knoll above mentioned is a kame, composed of sand and gravel. Boring S-9-3 penetrated 18 feet of these materials and then encountered diabase bed rock. This kame is very pervious and treatment, such as an impervious blanket, would be necessary to prevent an undue amount of seepage through it. West of the kame is a depression in which boring S-9-4 penetrated 24 feet of clayey silt containing sand laminae and then encountered rhyolite bed rock. This silt is impervious and since a dam here would have a maximum height of only 15 feet, there would be no question of settlement.

The west end of the dam would connect with the above mentioned sand and gravel ridge. This ridge is an esker and is probably composed of sand and gravel throughout. The flow line would be at the base of this ridge and the shortest path of seepage through it would be about 350 feet. The sand and gravel of this ridge are probably very pervious, but due to the fact that the head of water upon the ridge is so low it is possible that seepage might not be serious. It is, however, certain that a very thorough study of the seepage problem here is desirable and much additional sub-surface information should be obtained. If serious seepage is indicated by further study the silt blanket in the depression could be artificially extended on to the ridge thus effectively preventing seepage. If the water level in the reservoir should ever be raised, the seepage problem would become very much more serious and the ridge would certainly require treatment.

At the southern end of this esker ridge is a broad saddle before the main hillside to the south is reached. The lowest point in this saddle is at elevation 125 or 5 feet below the proposed crest of the dams. A low dike about 450 feet long with a maximum height of 5 feet would therefore be necessary to close this gap. Since the base of this dike is above flow line and the seepage path under it at flow line level would be about 600 feet long, there is little probability of seepage here.

This is a feasible dam site and the only problem is that of seepage under the knoll and through the ridge at the west end of the site. A thorough study and probably some type of treatment will be required here.

DAM SITE 10

Dam site 10 crosses a boggy saddle about 2 miles south of Whiting and immediately south of an open heath. A dam will extend from the easterly end of Bear Ridge eastward to high ground on the old Whiting-Cutler road. The lowest elevation on the line of dam is 117 or only 3 feet below the flow line and therefore this will be merely a low dike with a maximum height of 13 feet. The heath north of the dam site is underlain by more than 40 feet of soft clayey silt and the boggy area south of the heath is probably also underlain by similar material. Apparently the best possibility of favorable foundation conditions is to be obtained by following the slightly winding ridge which extends across this saddle. There are two low places in this ridge. In the western one a small brook flows north into the heath. The divide at the head of this brook, a few hundred yards to the south appears to be low and boggy and does not offer a favorable site for a dam. The eastern low place is boggy for about 100 feet. Boring S-10-4 at this place penetrated 32 feet of variable silty fine to medium sand mixed with gravel, cobbles and small boulders. This material will provide stable foundation conditions.

In the western low place in this ridge is a deep test shaft, S-10-TP-1, which penetrated 31 feet of overburden and did not reach rock. The upper part of the overburden is silty and the lower part is sand and gravel.

The borings in this ridge, the deep test shaft and several shallow test pits show that this ridge is composed of sand and gravel with varying amounts of silt. At the deep test pit the sand is well blanketed by clay and silt but this blanket does not extend up over the ridge. If the flow line were higher there would be considerable seepage through the ridge but with the flow line at elevation 120 the head would be so low that there could not be serious seepage. It is probable that the clay blanket comes up to the flow line but if this is not the case it could be very easily remedied if subsequent investigation should indicate the need of any treatment.

There can be no question of settlement here and since the dam is so low with very little head there is probably no seepage problem. By making use of this ridge a very satisfactory dam site can be obtained here.

DAM SITE 12

Dam site 12 crosses the abandoned Whiting-Cutler road on the divide between East Stream and Spring brook. The elevation at the lowest point of the survey line is 109 feet but in the saddle, 200 feet to the south the lowest elevation is approximately 118 feet or only 2 feet below the flow line. The maximum height of the dam would therefore be only about 12 feet but it would have a length of approximately 1,300 feet, and northwest of the main dam a low dike, some 900 feet long would be necessary across a broad low saddle which has a minimum elevation of 121 feet or 1 foot above the flow line.

Two borings were made at this dam site; boring S-12-1, on the lowest part of the line, penetrated 26 feet of silty sand and gravel and encountered rhyolite bed rock at an elevation of 83 feet. Boring S-12-8 penetrated 50 feet of fine to coarse sand with varied mixtures of sand and gravel below which were 40 feet of silty fine sand with some coarse sand and gravel. Bed rock was not reached at the bottom at elevation 32. The upper 50 feet is rudely stratified and contains layers and lenses of sand which is very pervious.

This dam site crosses a buried valley which extends southwesterly from the valley of East Stream. This valley is here blocked by a glacial deposit of sand and gravel on either side of which are low boggy areas. This sand and gravel ridge crossing the valley furnishes stable foundations for the dam but there will be a seepage problem even though the head is low. If a dam is built at this site, it will be necessary to obtain more information by borings and test pits in regard to the permeability of the materials at the dam site and some form of treatment such as an impervious blanket on the reservoir side of the dam will probably be necessary. The boggy ground on the reservoir side of the dam site is undoubtedly underlain by silt or other impervious material and it would be a simple matter to artificially extend this natural blanket up above the flow line, thus greatly reducing possible seepage.

Dam site 12 has foundation conditions sufficiently stable for a dam of much greater height but there is a seepage problem here and further investigation in the form of borings and test pits should be made if a dam is to be built at this site. It is probable that sufficient treatment to prevent seepage would not be a serious matter and this is, therefore, a feasible dam site.

DAM SITE 13

Dam site 13 will cross a brook at a point 1.3 miles west of Moose River and downstream from Barren Meadows. The elevation of the brook at the dam site is 70 feet and the height to the crest of the dam will therefore be 60 feet. The length of the dam would be nearly 1,500 feet. On the northern side of the valley is a bed rock bench and there is a shallow depression between this and the hillside. On the southern side of the valley is a terrace about 40 feet above the brook. Diabase bed rock is exposed on the hillside and bench north of the brook and was seen at one place on the terrace south of the brook.

The five borings made at this site indicate that this is a valley type dam site but that the deepest part of the bed rock profile is probably not more than 10 feet below the elevation of bed rock in boring 3-13-3. On the west side of the stream is a bed rock bench separated from the hillside by a depression, as has been described, and on the east side of the stream is another bed rock bench, also separated from the hillside by a depression in the bed rock surface. This bench is covered by a gravel terrace.

Boring 3-13-3 was drilled in the brook and encountered diabase bed rock at elevation 58 under 10 feet of silty sand and gravel. Boring 3-13-2 on the terrace 125 feet south of the brook found bed rock at elevation 99 under 11 feet of sand and gravel and boring 3-13-1 on the south side of this terrace, near the hillside encountered diabase bed rock at elevation 96 under 14 feet of overburden which consisted of 2 feet of boggy soil, 7 feet of silty sand and gravel, and 6 feet of silt. Half way between these borings bed rock outcrops. These borings indicate that the material at the southern side of the terrace is not very pervious but at the northern side of the terrace and under the brook the overburden is pervious. It is probable that some treatment to reduce seepage would be necessary. The maximum depth to rock shown by the borings is only 13 feet but it may be 5 to 10 feet deeper immediately east of the brook. Therefore, additional subsurface information to determine the need of treatment and the feasibility of a cut-off is desirable.

Boring 3-13-4 is in the small depression between the rock bench and the northern hillside; diabase bed rock was encountered at elevation 81 under 13 feet of overburden which consists of 6 feet of boggy soil and 7 feet of gravelly and silty sand which is somewhat pervious. Probably the blanket of impervious boggy material would prevent seepage here but if this blanket is found not to be continuous or sufficiently impervious, it would be necessary to extend the cut-off to bed rock.

There is no settlement problem at this dam site but there is a seepage problem and treatment might be required at the brook and on the terrace south of the brook to prevent an undesirable amount of seepage. Additional subsurface information to determine the extent of the seepage problem and the best type of treatment is recommended if a dam is to be constructed at this site.

DAM SITE 14

Dam site 14 is across a broad saddle between two hills about one and a quarter miles north of Moose River. This saddle has a long, gentle slope from the eastern hillside to a low point at elevation 112 immediately west of which is a knoll rising to 135 feet. Between this knoll and the western hillside is another depression with a low point at 118 feet. A dam here would be only 12 feet high and about 1,200 feet long.

Two drill holes and several shallow test pits were made at this site. Boring S-14-1 at the low part of the main saddle encountered diabase bed rock at elevation 95 under 16 feet of silty sand and gravel which is pervious. Three test pits east of this boring exposed sand and gravel with a varying amount of silt. Test pit S-14-TP-5 ended on a ledge or boulder at an elevation of approximately 127 feet but test pit S-14-TP-6, about 370 feet farther east did not strike rock at elevation 126, and it is, therefore, doubtful that bed rock was reached by the other test pit. The overburden on this part of the dam site is somewhat pervious and since the thickness of the overburden on the eastern part of the site is uncertain it would be desirable to have additional information about the depth of rock and character of the overburden, and, therefore, two additional drill holes about 400 and 800 feet east of boring S-14-1 are recommended if a dam is to be built at this site.

The character of the knoll in the western part of the saddle is unknown but it is probably a glacial deposit of sand and gravel. Boring S-14-2 in the depression between this knoll and the western hillside penetrated 6 feet of sandy silt, with phases of gravelly, silty sand, and 16 feet of soft clayey silt. Diabase bed rock was reached at elevation 94. There might be a minor settlement problem here but it can hardly be important with this very low dam. The upper layer is pervious but since it is only a few feet thick a cut-off to the silt would be a very simple matter.

The western end of the dam would connect with the ridge in which bed rock is not exposed. The character of the material in this ridge is uncertain but it may be sand and gravel and this should be investigated to determine whether there is any possibility of seepage around the end of the dam.

Dam site 14 is a feasible dam site but it has a minor seepage problem and more information is needed but it is probable that any treatment required on this site would not be a serious matter.

BORROW MATERIAL

Harry A. Hall

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The Haycock Harbor Reservoir Site Borrow Exploration was suddenly suspended after two months of work. At this time, the proposed program had been but partially carried out. An immediate schedule consisting of the digging of 150 pits was about to become effective. At the cessation of work on January 8, the aggregate investigated borrow was about 1,000,000 cubic yards short of the total amount of material necessary in the construction of the dams. It is thought that completion of the program, would disclose material well in excess of the needed amount.

Three hundred odd test pits were dug and sampled. The average pit dimensions were 4' x 5' x 6' deep. Material on the whole was of a medium grade, being neither too poor, nor exceptionally good. In this report, only suitable material is discussed. This is divided into three groups:

1. A glacial till, composed of silt, sand, pebbles, gravel, with or without clay, which is suitable material for the core of a rolled fill embankment. It is impervious, due to the fines, and is able to withstand pressure due to its combination of bonded silt, gravel and pebbles.

2. Sandy silt, with or without pebbles, which is sufficiently impervious for the core of a rolled fill.

3. Unstratified gravel and sand. This is pervious but can be used for pervious fill or possibly for impervious fill by mixing and placing by hydraulic methods.

A total borrow of nearly 6,000,000 cubic yards is necessary in the construction of the 12 dams. At the time operations were stopped, an estimated borrow of some 5,000,000 cubic yards of usable material had been partially investigated. In and about the Reservoir Site there exists a probable borrow, as yet unexplored, of 3,000,000 cubic yards. In most of the areas in which pits are located, a depth of only 2 yards, as indicated by 6-foot pits, was used in computations. Areas were also conservatively estimated as no surveys had been made of the deposits.

Further investigation in these areas, consisting of drilling to determine actual depths of deposits, and surveys to obtain actual areas, should be made to ascertain, with a greater degree of accuracy, the borrow available. In view of the conservative borrow estimates here made, it is entirely probable that even in areas investigated, considerable more material would be found to be available upon receipt of more detailed and accurate exploratory information.

The areas explored are assigned to the nearest dam site, and are designated as Deposit 1, 2, etc. Material in any deposit, in excess of that required for that immediate dam, would be used in other dams having a deficiency.

The borrow areas will be taken up according to dam sites. Materials contained therein will be discussed, using information from the Soils Laboratory and observations in the pits.

(Note:-See accompanying maps in conjunction with below discussion)

DAM F.

Deposit 1 is a partially explored, heavily wooded ridge 2,800 feet to the north of the center line of the dam. Upon this ridge are located pits 3-F-BT 20-22, and as indicated by these pits the material is pervious but suitable for fill. Pit 21, however, shows portions of impervious borrow. More extensive exploration is needed here to determine the extent of the impervious material. The ridge is very definite, rising some 28 feet from surrounding land, and it probably consists of similar material throughout. Therefore, although pits indicate a positive known depth of only 8 feet, an estimated depth of 15 feet was used giving a borrow of 500,000 cubic yards.

Deposit 2 is 2,000 feet to north of the dam site. Areas to the north of this will also bear investigation. This area contains several ridges and is probably a continuation of Deposit 1. Pits 3-F-BT-23-30, inc., are located on the various ridges. An estimated depth of 12 feet was used and the estimated borrow is 480,000 cubic yards.

Deposit 3 is 1,000 feet northwest of the dam site and is a small deposit of pervious material, as indicated by pits 3-F-BT 32-34, inc. Actual pit depths were used in the borrow computations, giving an estimated borrow of 80,000 cubic yards.

Deposit 4 is 2,000 feet to the south of the dam site. A secondary road, called Cross Road, cuts this area, which consists of a series of ridges running east and west, and crosses the center line of the dam. Haul will be greatly facilitated due to this fact. This vicinity is covered by Pits 3-F-BT 3-17, inc. The material is suitable for impervious rolled fill construction and the estimated borrow is 130,000 cubic yards.

Deposit 5 is similarly located on Cross Road, 2,500 feet north of the dam site. The material, however, is of a pervious nature. Pits

3-F-BT 108-114 were dug here. The estimated borrow is 250,000 cubic yards.

Deposit 6 is 5,000 feet north of the dam site. In this area, are pits assigned to Dam 6 but the material will be used for Dam F. This material, as indicated by pits 3-F-BT 38, 41-43, 50, 51 and 3-6-BT 101, 30, 40-46, is suitable for impervious rolled fill construction. The estimated borrow is 165,000 cubic yards.

Deposit 7, 1,000 feet south of the dam site is an esker, rising sharply from the surrounding land. Although pits 3-F-BT 1, 2, were dug here to a depth of five feet only, an estimated depth of ten yards is used. One of these pits disclosed excellent material for rolled fill construction, while the other showed a pervious gravel. More exploration is necessary here to determine the exact nature and extent of the deposit but with the present information an estimate of 100,000 cubic yards is made.

Deposit 8, 700 feet south of the dam site, and the succeeding three areas, were first assigned to Dam 2. Since this dam has been abandoned, however, the material would be used for Dam F. Pits 3-2-BT 11, 12, show this ridge to be of a pervious nature. The estimated borrow is 50,000 cubic yards.

Deposit 9 in which are pits 3-2-BT 8, 13, is 800 feet south of the dam site. It is possible that this material is usable for impervious rolled fill. The estimated borrow is 20,000 cubic yards.

Deposit 10 is 1,200 feet southeast of the dam site. As indicated by pits 3-2-BT 11, 2-4, this material is probably too pervious for impervious rolled fill, but is suitable for other fill. The estimated borrow is 30,000 cubic yards.

Deposit 11 is 1,500 feet southeast of the dam site. Qualitative and quantitative analyses of this deposit are made on the basis of one sampled pit. This is a gravel pit, tapping the western edge of a deposit. The area and average depth are, therefore, estimated. The material is a pervious gravel and sand, with lenses of clay. Further analyses may show the mixture to be suitable for rolled fill construction. The estimated borrow is 25,000 cubic yards.

The total calculated borrow for Dam F is 1,810,000 cubic yards and the amount required is 2,869,000 cubic yards. This estimate, and those following are based on investigated areas only, and by no means constitute all the deposits of borrow material.

DAM 3.

Deposit 1, 2,000 feet northwest of the dam site is a heavily wooded ridge, on which are pits 3-3-BT 1, 3-8. The material is suitable for rolled fill construction and a 4-yard depth is used in obtaining the estimate of 250,000 cubic yards.

Deposit 2, 1,000 feet east of the dam site, consists of cultivated blueberry fields. The material, although pervious, is suitable for fill. Pits 3-3-BT 40-44 are located here. The estimated borrow is 30,000 cubic yards.

Deposit 3 is 500 feet south of the dam site. As shown by pits 3-3 BT 20-23, this deposit is pervious, but can be used for fill. The estimated borrow is 30,000 cubic yards.

Deposit 4 is 1,200 feet south of the dam site. Parts of this area are sufficiently impervious to be used as a rolled core. The remaining parts are too pervious, but can be used for other purposes. In the area are pits 3-3-BT 5, 6, 101-103, and the estimated borrow is 50,000 cubic yards.

1,000 feet to the southeast of Deposit 4 lies a borrow area upon which insufficient information is available to warrant an estimate. Pits 3-3-BT 24 and 25 are located here.

The total estimated borrow for Dam 3 is 360,000 cubic yards and the amount required is 213,000 cubic yards. Any surplus material can be used for Dam F.

DAM 4.

Deposit 1 is 1,000 feet to the west of the dam site. This ridge, as indicated by pits 3-4-BT 4-7, is impervious, and suitable for rolled fill. Existing roads from deposit to dam site render haul a simple matter. The estimated borrow is 30,000 cubic yards.

Deposit 2, 1,000 feet to the west of the dam site, is similar in topography and material to Deposit 1. Pits 3-4-BT 10-14, indicate impervious material. The estimated borrow is 30,000 cubic yards.

The total estimated borrow for Dam 4 is 60,000 cubic yards and the amount required is 35,000 cubic yards.

DAM 5.

Deposit 1 is 1,500 feet to the west of the dam site. A gravel pit, 3-5-BT 105, was sampled and indicates a pervious gravel. Although no other pits were located on this deposit an estimate of 5,000 cubic yards, based on visual inspection, is made.

Deposit 2 is 2,500 feet west of the dam site and the haul would be made on the Wilson Road. Pits 3-5-BT 106 and 106A are used in obtaining an estimate of 15,000 cubic yards.

Deposit 3, 800 feet west of the dam site, consists of a large cultivated blueberry ridge. Pits were spotted here, but not dug, due to the landowner's objection. This deposit contains sufficient material to construct Dam 5 and have a large surplus.

The total calculated borrow for Dam 5, omitting deposit 3, is 20,000 cubic yards and the amount required is 500 cubic yards. The surplus material could be used for Dam 6 or Dam 7.

DAM 6.

A gravel pit, 3-6-BT 101 was sampled. Insufficient information is at hand, however, to make a quantity estimate. As is noted under Dam 5, a sufficient surplus is there obtainable to construct Dam 6.

The residual borrow of Dam 5 available for Dam 6 is 19,500 cubic yards and the amount required is 7,500 cubic yards.

DAM 7.

Deposit 1 is 1,000 feet north of the dam site. This entire section, called Chapel Hill, is a hugh deposit of gravel, and sand in which is the deep test pit, 3-7-TP-1. This pit is 49 feet deep and shows fine sand, and gravel material. As the center line of Dam 7 passes over part of this area, it is questionable as to how much of this material would be available for borrow. At the northern extremity of the deposit is a gravel pit, 37-BT 6. Material as here indicated is pervious, but suitable for fill and the estimated borrow from this part of the deposit is 80,000 cubic yards.

Deposit 2, 7,000 feet north of the dam site, is an aggregate of 12 small deposits consisting of small ridges running east and west. Although at a considerable distance from the dam site, they are all accessible, in that a road passes through them to the dam site. Pits 3-7-BT 3-5, and 22-32, indicate a pervious gravel, and the estimated borrow is 262,000 cubic yards.

Deposit 3 is 6,000 feet north of the dam site and as indicated by pits 3-7-BT 34-38, the material is pervious. Further exploration will probably show more material in this vicinity but the present information justifies an estimate of only 80,000 cubic yards.

The total estimated borrow for Dam 7 is 422,000 cubic yards and the amount required is 1,082,000 cubic yards. Further exploration of Deposit 3 will probably disclose a borrow of much greater proportions than above shown.

DAM 8.

Deposit 1, 1,000 feet south of the dam site, consists of two ridges of impervious material which can be used in rolled fill construction. Pits 3-8 BT 4-6, 30-32, located in this area indicate an estimated borrow of 50,000 cubic yards.

Deposit 2, 4,000 feet south of the dam site, is a broad expanse of gravel ridge. On it pits 3-8BT 9, 10, 16-21 show pervious material which is usable for fill. Hood's Gravel Pit in which is pit S-8-10, has been extensively used in road construction, and is an excellent concrete aggregate. Extensive tests of this gravel have been made at the State Testing Laboratory at the University of Maine. The estimated borrow is 545,000 cubic yards.

Deposit 3, 5,000 feet southwest of the dam site, is a partially explored ridge showing a material varying from pervious to impervious. Further investigation here is warranted. Pits S-8-BT-21-22, were dug here and the estimated borrow is 240,000 cubic yards.

Deposit 4 is 6,000 feet southeast of the dam site. Material in this high, cultivated blueberry ridge is suitable for rolled fill construction. Pits S-8-BT 11-14 are located here and further explorations will show some additional borrow to the northeast. Using the present available information, the estimated borrow is 320,000 cubic yards.

The total estimated borrow for Dam 8 is 1,161,000 cubic yards and the amount required is 1,030,000 cubic yards. Further exploration will probably show sufficient additional material.

DAM 9.

North and northwest of the dam site is an extensive gravel ridge, apparently an esker, in which two pits were dug and others were planned. It is possible that sufficient material of a pervious nature is obtainable here to construct the dam.

The amount required is 286,000 cubic yards.

DAM 10.

Deposit 1 is 1,500 feet west of the dam site, on the eastern end of Bear Ridge. Two pits S-10-BT 1A and 2 showed material which is probably impervious enough for a roller fill. Additional pits were planned along this ridge, which is some 2,000 yards long. From the present information the estimated borrow is 60,000 cubic yards but a borrow of 800,000 cubic yards in this ridge is possible.

Deposit 2 is 800 feet east of the dam site. One pit here, S-10 BT 1, indicates a fairly impervious sand, gravel, silt, and clay. More pits are desirable in this area. From the available information an estimate of 40,000 cubic yards is made.

The total estimated borrow for Dam 10 is 100,000 cubic yards, and the amount required is 81,000 cubic yards.

DAM 12.

Deposit 1, is 1,200 feet north of the dam site. Two pits, S-12-BT 1 and 2, show a pervious material, possibly suitable for hydraulic fill. This deposit, on the side of Long Ridge, is about 1,000 yards long. Further exploration is needed, but at present a conservative estimate of 40,000 cubic yards is made. However, a borrow of 600,000 cubic yards in this ridge is possible.

The total estimated borrow for Dam 12 is 40,000 cubic yards, and the amount required is 30,000 cubic yards.

DAM 13.

Deposit 1, 800 feet from the dam site, is on a rock bench on the hillside. Due to scarcity of borrow for this dam, however, an extensive pit layout was made here. As shown by pits S-13-BT 1-18, the material is pervious but suitable for fill. In view of the lack of borrow for this dam, the depth of this deposit, 6 feet, as indicated by the pits, might warrant use as a source of supply. Estimated borrow is 140,000 cubic yards.

Deposit 2 is 8,000 feet southeast of the dam site. Although first assigned to Dam 16A, this material is available for Dam 13, due to abandoning of Dam 16A. Pits S-16A-BT 1 and 2 show a fairly impervious material, and the estimated borrow is 21,000 cubic yards.

Deposit 3, 9,000 feet southeast of the dam site, was likewise allotted to Dam 16A. The material as indicated by S-16A-BT 3, located in a gravel pit, is pervious, but suitable for fill. The estimated borrow is 45,000 cubic yards.

Deposit 4 is about 4 miles from the dam site. Two pits, S-13-BT 40 and 41, were in large gravel pits, on the Cutler Road. These are located on a large blueberry ridge which will show much more available material upon further investigation. Although at a considerable distance from the dam site, an improved road haul can be used. A very conservative estimate of 120,000 cubic yards was made but a very much larger amount could probably be obtained here.

Ten pits were planned along the Cutler Road. These were located in and about existing gravel pits. Sufficient gravel with an average haul of 2 miles could be here obtained to render unnecessary the long haul from Deposit 4.

The total calculated borrow for Dam 13 is 326,000 cubic yards and the amount required is 240,000 cubic yards.

DAM 14.

One pit only was assigned to Dam 14 but this proved unsatisfactory, as ledge was struck at 3.5 feet. The required material can probably be obtained, however, on the ridge at the west end of the dam site. This is in Lots 44, 45 and 46. (Map C-1-43.) Ten pits were planned in this area but had not been dug when work was stopped.

The amount required is 77,000 cubic yards.

CONCLUSIONS

Although present exploratory information has not disclosed, within short haul distance, the amount of borrow necessary for 4 dams, namely, F, 7, 9 and 14, it is this writer's opinion that completion of the proposed borrow pit program would show suitable material in sufficient quantities to make up this deficit.

CONCLUSIONS

The important geological problems in connection with the Haycock Harbor storage reservoir are concerned with the overburden more than with the bed rock. Although bed rock is in places much cut by joint cracks, and belts of slate occur, it is in general satisfactory for foundations or can be made so by grouting. It is highly improbable that the condition of the bed rock will anywhere cause serious difficulties.

As regards the overburden, conditions are not so favorable and two serious problems are presented. These are: the presence of thick beds of clay at some of the dam sites, and the existence of deposits of pervious sand and gravel at several of the sites.

Where the dams will rest upon clay there may be slow settlement of the structure and possibly in the case of the softer clay danger of failure of the dam by movement of the clay, but the worst conditions of which are any indication can be met by designing the dams with flatter slopes and using greater quantities of earth in them.

The settlement problem is known to exist at the sites of Dam F, Dam 3, Dam 4 and Dam 8A. At some of these sites the clay is thicker and softer than at others and the situation is more serious, but at each of the sites named and possibly at some others, the problem exists and must be studied and met.

Seepage problems are known to be important at dam sites F, 7, 8, 9, 12 and 13 and should also be studied at the west end of 14 and possibly at some other sites. It is probable that treatment will be required at sites F, 7, 9 and 12, and possibly elsewhere. The seepage problem would be more important here than at the Calais Reservoir.

A third serious problem is the location of borrow pits from which to obtain material for the construction of the earth dams. It is possible but not yet proved that a sufficient quantity of suitable material for the dams can be obtained. Much of this material is known to be too pervious for use in the impervious core of a rolled filled dam. Some of this pervious sand and gravel can be used in the outer pervious sections of the dams but it is probable that in order to obtain sufficient embankment material it will be necessary to place much of the material by hydraulic methods thus concentrating the fines in the core.

The borrow pit situation is far from ideal and the fact that much of the material is in widely scattered small deposits and that a considerable proportion of it is unsuitable for impervious rolled fill embankment construction would increase the cost of construction of these dams.

In brief, although this project is feasible and no insurmountable difficulties will be encountered, there will be problems with seepage, settlement of structures founded upon clay, and difficulty in obtaining suitable embankment material. All of these problems will increase the costs of construction. It is believed that all the geological conditions are more favorable at the Calais Reservoir.

Respectfully submitted,

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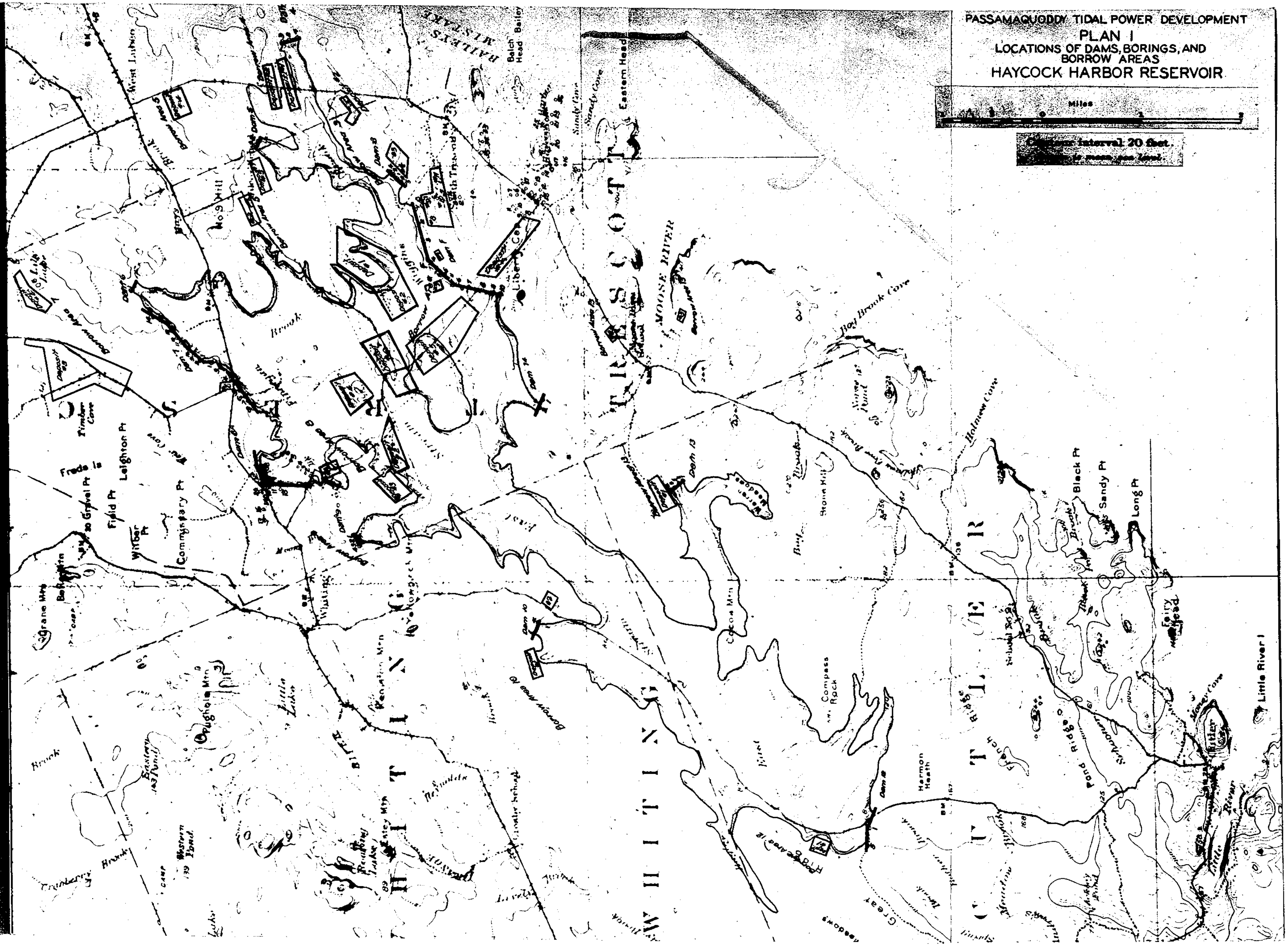
6 Beacon Street
Boston, Massachusetts

March 5, 1936.


PASSAMAQUODDY TIDAL POWER DEVELOPMENT
PLAN I
LOCATIONS OF DAMS, BORINGS, AND BORROW AREAS
HAYCOCK HARBOR RESERVOIR
Miles
interval 20 feet
Eastern Head
Sandy Cove
Bay Brook Cove
Holmes Cove
Black Pt
Sandy Pt
Long Pt
Fairy Head
Little River I
Pond Ridge
Harmon Heath
Compass Rock
Cocoa Mtn
Stone Hill
Dam 13
Dam 10
Dam 14
Frede Is
Gravel Pt
Field Pt
Leighton Pt
Wilbur Pt
Commissary Pt
Timber Cove
Crane Mtn
Roaring Lake
Western Pond
Cranberry Brook
Brook
MOOSE RIVER
Little Lake
Western Pond
Great Meadows

WAR DEPARTMENT

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PASSAMAQUODDY TIDAL POWER DEVELOPMENT

PLAN 2

DAM SITE F HAYCOCK HARBOR RESERVOIR

GENERALIZED GEOLOGIC SECTION

U. S. ENGINEER OFFICE, EASTPORT, MAINE MARCH 1936.

SUBMITTED: APPROVAL RECOMMENDED: APPROVED:

HEAD ENGINEER | CAPTAIN, CORPS OF ENGINEERS CHIEF, ENGINEERING DIVISION | LT. COL., CORPS OF ENGINEERS DISTRICT ENGINEER

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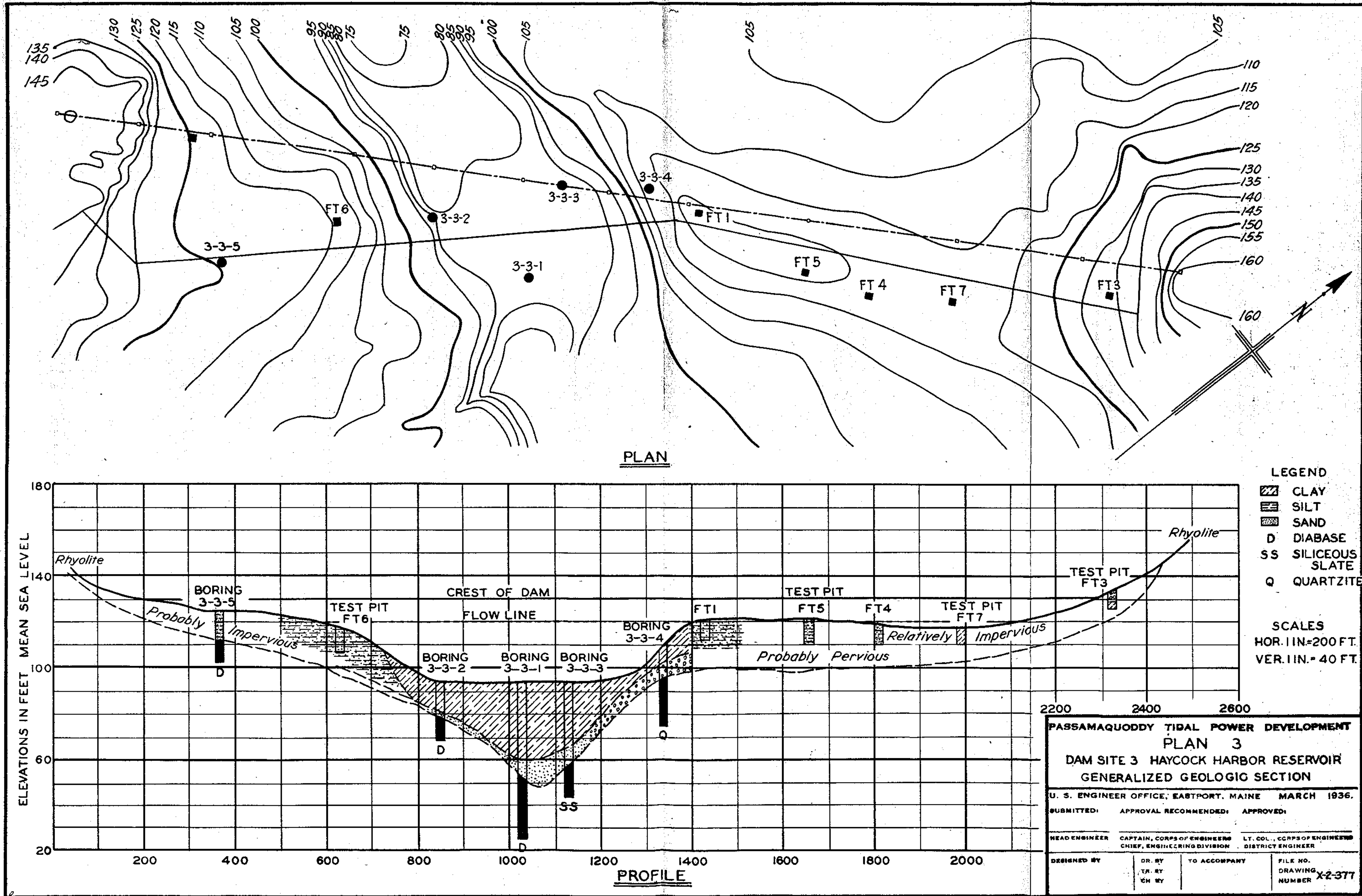

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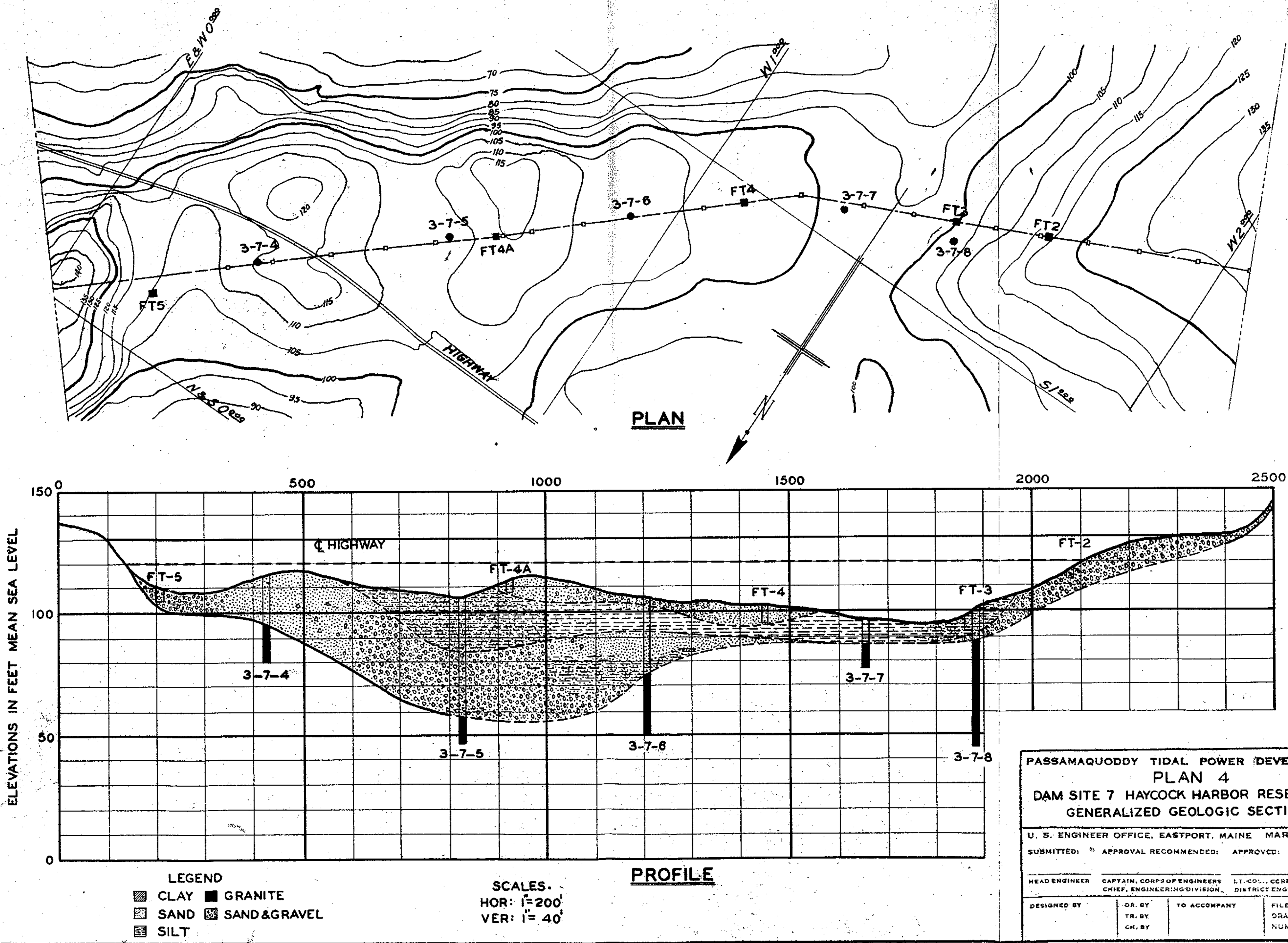

PASSAMAQUODDY TIDAL POWER DEVELOPMENT

PLAN 4

DAM SITE 7 HAYCOCK HARBOR RESERVOIR

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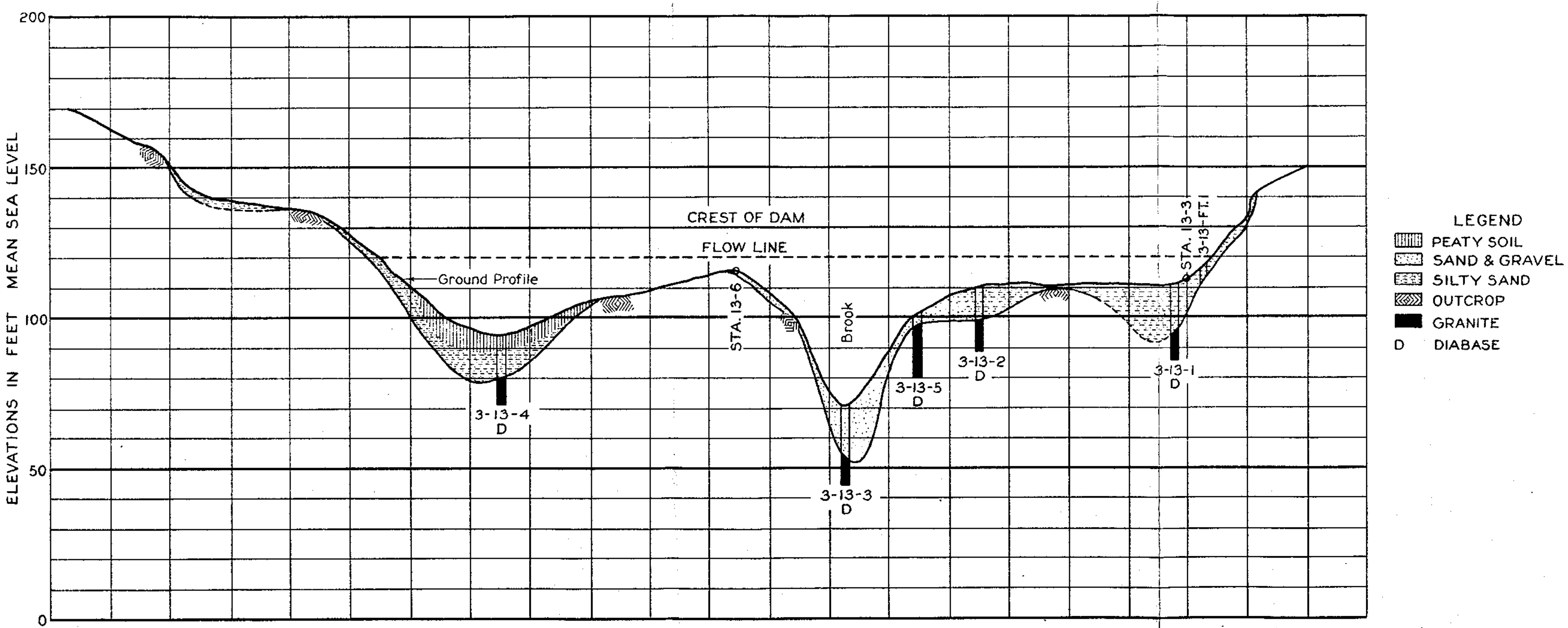

PROFILE

SCALES

HOR. 1 IN. = 200 FT.

VER. 1 IN. = 40 FT.

PASSAMAQUODDY TIDAL POWER DEVELOPMENT

PLAN 5

DAMSITE 13 HAYCOCK HARBOR
GENERALIZED GEOLOGIC SECTION

U. S. ENGINEER OFFICE, EASTPORT, MAINE — MARCH 1936

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